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published in
Clinical Rehabilitation
2000

DOI (link to publisher)
10.1191/026921500674930367

document version
Publisher's PDF, also known as Version of record

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Clin Rehabil 2000 14: 247
DOI: 10.1191/026921500674930367

Clinical Rehabilitation 2000; **14**: 247–259

The efficacy of Le Bon Départ and Sensory Integration treatment for children with developmental coordination disorder: a randomized study with six single cases

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Received 28th June 1999; returned for revisions 29th September 1999; revised manuscript accepted 18th November 1999.

Objective: Evaluation of the efficacy of Le Bon Départ (LBD) treatment and Sensory Integration (SI) treatment on motor performance of children with developmental coordination disorder.
Design: A single subject design with multiple baseline and alternating treatments. Order of treatment and length of phase were randomized. Measurements were blinded.
Setting: Department of Occupational Therapy at the Academic Hospital Vrije Universiteit Amsterdam, The Netherlands.
Subjects: Five boys and one girl with developmental coordination disorder (age: 6.0–8.1 years).
Interventions: Baseline condition, Le Bon Départ treatment and Sensory Integration treatment.
Main outcome measures: The Movement ABC, Praxis Tests, a rhythm test and visual analogue scales. With the exception of the Praxis Tests, lower scores indicate better performance.
Results: During both treatments, the performance on the Movement ABC ($\bar{x}$ = 7.21) and the scores on the visual analogue scales ($\bar{x}$ = 46.64) were significantly better than in the baseline (Movement $ABC_{baseline}$: $\bar{x}$ = 17.38; visual analogue $scales_{baseline}$: $\bar{x}$ = 68.18). After treatment 2, performance on the Praxis Tests and scores on the visual analogue scales were significantly better than after treatment 1 (Praxis Tests: 113.54 versus 104.68; visual analogue scales: 34.74 versus 58.54). All six children performed better on the Movement ABC during treatment as compared to the baseline. Le Bon Départ led to significant improvement on all dependent variables, Sensory Integration

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0269–2155(00)CR322OA

on the visual analogue scales only. The improvements after Le Bon Départ were larger than the improvements after Sensory Integration treatment. On the rhythm test this difference was significant: LBD led to an improvement of 43.01 points, while the improvement after SI was 17.59 points ($p < 0.05$).
Conclusion: Motor performance of children with developmental coordination disorder improved significantly on all dependent variables after the combination of treatments. Le Bon Départ led to more improvement than Sensory Integration. LBD appears to be a valuable treatment method for children with developmental coordination disorder.

Introduction

The popularity of children is often related to their proficiency in sports and games, and being physically competent is highly valued by children.[1] The movement difficulties of developmentally delayed children may invite ridicule from their peers. These children are often caught in a vicious circle of demonstrated incompetence, a low level of self-esteem, being excluded from play and games[2] and further motor delay due to the lack of practice. Interventions could help the child to catch up with at least some of this delay. In the present study, the effects of two treatment methods for children with movement problems are evaluated.

Children with movement difficulties have been characterized with a variety of terms such as 'poorly co-ordinated', 'developmentally dyspractic' or 'clumsy'. In this paper, the term 'developmental coordination disorder' (DCD)[3] will be used. Children with DCD have poor motor performance for their age that is not explainable by mental retardation or any known physical disorder, and which interferes with academic achievement and activities of daily living. Descriptions of the specific symptoms of DCD include poor coordination of gross movements, difficulties with fine movements such as writing or rhythmic finger movements, inconsistency of performance, cognitive disorders, perceptual deficits, and social or affective problems.[4–7]

The prevalence of DCD is estimated to be 6% for children in the age range 5–11 years.[3] The often heard opinion that children 'will grow out of their movement difficulties' has been refuted by a number of studies.[8,9] Treatment is thus of paramount importance. In this respect, however, there are several problems. The pathological mechanisms underlying DCD are largely unknown,[10–12] and there are serious questions about the efficacy of the sensorimotor programmes that are usually prescribed.[13,14] In the Netherlands, Sensory Integration (SI) is often administered. A less commonly used alternative is the treatment method 'Le Bon Départ' (The Good Departure).[15]

Le Bon Départ (LBD) is a form of psychomotor therapy in which music and rhythm play a prominent role. The method was originally developed by Thea Bugnet[16] as an educational method for toddlers to prepare them for writing education. To date, LBD is also used as a treatment for developmentally delayed children in the Netherlands, Belgium, France, Portugal, Spain, Switzerland and Poland. The literature on LBD suggest efficacy[17–21] but no randomized intervention studies on children with motor problems are available. The present study presents the first randomized evaluation of the LBD method for children with DCD, comparing it with a baseline condition and with SI treatment.

Methods

Subjects

To reduce the impact of heterogeneity,[22–24] a stepwise intake procedure was applied.[25,26] First, class teachers and physical education teachers of 29 regular primary schools in Amsterdam selected children between 5 and 8 years old who, in their judgement, had poor motor coordination. Children and parents had to speak Dutch. Children with marked learning disorders, hyperactivity or other behavioural disorders were excluded in advance, as were children in a situation that could interfere with their day-to-day functioning, such as recent divorce of parents. No exact definitions were formulated for these exclusion criteria, and the decision for exclusion was based on the opinion of the teachers.

Subsequently, teachers and parents filled in the Groninger Motor Observation Scale (GMOS),[25] a checklist to select children 'at risk' for DCD. Children were included when the scores of both teachers and parents were above the 70-centile. In this way, 25 children were selected. These children were tested with the Movement ABC.[27] Eight children scored within the normal range (>15-percentile) and were excluded. Four children with borderline motor performance (>5 and <15) were advised to receive other treatment. The parents of three of the 13 children with 'a definite motor problem' (<5 percentile)[27] preferred to have their child treated elsewhere. Finally, the ten remaining children were examined by a child neurologist to exclude specific neurological problems. Two children were dyslexic, one child had a congenital problem, and one suffered from epilepsy. The final study sample consisted of six children with DCD, five boys and one girl (6.0–8.1 years). Parents signed an informed consent.

Design

Given the heterogeneity and day-to-day variability[28–30] of symptoms in DCD, a single case methodology was chosen with several forms of experimental control[31] to increase the internal validity of the study (Figure 1). To control for 'spontaneous' improvement, the length of the baseline condition was randomized per child to between 12 and 18 weeks. To control for placebo, children were given special attention during the baseline condition. Baseline was followed by alternating between LBD and SI. To control for carry over, the order of treatments was randomized so that three children first underwent LBD and three first SI. LBD as well as SI were provided by an experienced therapist in weekly one-hour sessions at the Department of Occupational Therapy. In order to control for systematic seasonal effects, the number of weeks per treatment phase was randomly selected in the same manner as for the baseline.

Children were measured four times with the Movement ABC and the Praxis Tests: at intake and at the end of each 'phase'. The tester was blinded for phase and treatment order. In view of the variability of rhythmic scores,[5,29] Rhythm Integrated™ was administered three times per phase. Each week the parents filled in visual analogue scales (VASs) and delivered these to the Department.

The design was approved by the Ethical Committee of the Academic Hospital of the Vrije Universiteit.

Dependent variables

Movement ABC

The Movement ABC[27,28] evaluates manual dexterity, balance and ball skills. This standardized test has been widely used in intervention studies.[32,33] In the present study, the Movement ABC was used both as screening instrument and as dependent variable. Total scores were calculated. In a preliminary study,[28] it was established that the total score is sufficiently sensitive to

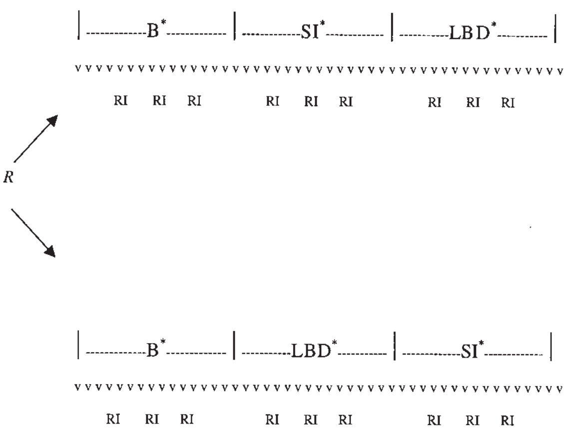

Figure 1 Study design. R, Randomization of the order in which LBD and SI are given. Vertical rules indicate assessment with Movement ABC and Praxis Tests (before the start of the baseline condition and after each phase). B, Baseline condition; *, phase length is randomized per child between 12 and 18 weeks; SI, treatment with Sensory Integration (12–18 sessions); LBD, treatment with Le Bon Départ (12–18 sessions); RI, assessment with Rhythm Integrated (spaced unevenly, the actual intervals between the tests within one phase are chosen for practical reasons); v, visual analogue scales filled in weekly by the parents.

reveal individual change, with a standard error of measurement (SEM[34]) of 3.13.

Praxis Tests

The six Praxis Tests of the SIPT[35] were used as dependent variable because SI specifically aims to reduce problems in sensory integration, and children with DCD often experience difficulties in planning and organizing movements. The Praxis Tests evaluate skills such as the translation of verbal commands into action, three-dimensional construction and imitating movements and positions. Since the maximum score per test varies, a weighted total score was calculated. First, the actual score on each separate test was divided by the maximum possible score on that particular test, and subsequently multiplied by the sum of all maximum scores on the six Praxis Tests together. Finally, these weighted scores were added to a total score. In a preliminary study, the test–retest reliability of this weighted total score of the Praxis Tests was found to be high (>0.9; SEM = 4.52).

The SIPT as a whole was also used as a diagnostic tool. Scores were translated into standard deviations from the norm in the child's age group (Table 1), and SI treatment was planned on the basis of these scores. Initial SIPT scores of all six subjects justified treatment with SI.

Rhythm Integrated™

Le Bon Départ (LBD) focuses on rhythmic performance. Children with DCD often have problems with producing a rhythm, or with switching from one rhythm to another.[5,36] Therefore, both a continuation and a switching task were evaluated using the computer package Rhythm Integrated™.[37] With the continuation task, children were asked to tap on the mouse button simultaneously with an auditory stimulus, and to continue this tapping 10 seconds after the stimulus stopped. With the switching task, the child was asked to tap along with a computer stimulus that suddenly switched from a low to a high frequency, and vice versa. Both tasks were performed with four different frequencies. Actual intertap intervals (ITIs) were registered by the computer.

Absolute error (AE) was calculated as the absolute difference between the mean intertap interval (ITI) of the child and the fixed ITI of the computer stimulus. For variable error (VE), the standard deviation of the child's ITI was used. CE and VE were averaged to form the total error (TE) (see ref.[38]). TE was averaged over all test conditions. In a preliminary study with 39 healthy children, test–retest reliability of this averaged TE was found to be sufficiently high (>0.8; SEM = 24.9 ms). Scores of these healthy subjects were used as a reference to calculate to what extent the children in the present study differed from their peers (Table 1).

Visual analogue scales (VASs)

Parents were asked to fill in three different forms, each with a statement concerning the (motor) functioning of their child. Parents had to quantify their worries by placing a vertical line crossing a 10-cm horizontal VAS.

This was done for the following items:

- The movements of my child are more clumsy than the movements of his/her peers.

Table 1 Initial scores on the Movement ABC, the Praxis Tests and Rhythm Integrated™

Subjects	Age (years and months)	M.ABC (points)	Praxis Tests (SDs)	Rhythm Integrated™ (SDs)
A (male)	8.1	15	0.52	0.31
B (male)	6.0	25.5	–0.69	–6.15
C (male)	7.6	13.5	–0.10	–2.79
D (male)	6.7	15	–0.33	–5.67
E (female)	7.6	17	–0.38	–2.42
F (male)	6.4	18	–0.09	–0.63

For the Praxis Tests, the scores are presented in standard deviations from the age norm.
The Movement ABC and the Praxis Tests were administered before the start of the baseline phase. For practical reasons, children were tested for the first time with Rhythm Integrated™ two weeks later. The scores of Rhythm Integrated™ are presented as standard deviations difference from the scores of the reference group of healthy subjects of the same age (see 'Method').

- I am worried that my child will experience several problems in the future because of his/her motor problems.
- My child is clumsy in several situations.

Scores were measured as millimetres from the left, ranging from 0 (no problem) to 100 (very serious). The total score was calculated by averaging the three scores. In a preliminary study, test–retest reliability of this total score was high (>0.9; SEM = 7 mm).

Interventions

Baseline condition

During the baseline condition, children and parents were advised to engage in movement games at home. These games, described in a notebook, varied from building a tent of sheets to baking cookies. To equate the professional attention typical of regular treatment, the children were seen once a week at the Department by a therapist or a tester. During this weekly contact, experiences with the 'homework' games were discussed. Furthermore, the remaining subtests of the SIPT were administered or the child was assessed with Rhythm Integrated™.

Le Bon Départ (LBD)

The rationale underlying LBD is that through development of rhythm, motor performance is positively influenced. Treatment with LBD is highly individualized and can be applied to address the specific problems of the child, for example writing or ball skills. Different musical instruments are used (drums, castanets, flutes), as well as materials such as ribbons, balls, sandbags and drawing utensils.

Before starting treatment, the therapist evaluates the motor functioning of the child with standardized tests. The child's drawing and writing is inspected, free play is observed and body perception is evaluated. Together with information from parents, teachers, psychological and/or medical records, these observations form the basis for treatment.

Treatment with LBD is divided into a preparation phase, a main learning phase and a period of variations. In the 'preparation phase', the general rules of the method are acquired through simple games. The child listens to sound and examines geometric shapes, following these visually and with the hands. In the main learning phase, geometric figures and accompanying songs are the essential components in a structured set of exercises. The figures are transformed into bodily experiences, varying from walking in a circle to drawing triangles. External rhythms are offered by the therapist and songs are sung by the therapist and/or the child. The rhythm of the music supports the coordination of the movements and defines their timespan. When the child is capable of performing the figures in an easy, well coordinated manner, the exercises are made more difficult by changing some of the features of the basic figures and the accompanying music.

Sensory Integration (SI)

SI is a noncognitive, movement-based therapy developed by AJ Ayres.[39] Ayres defined the object of SI as enhancing the brain's capacity to perceive and organize sensory information to produce a more normal, adaptive response, and thus to provide the foundation for mastering academic tasks. For details on this well-known method, we refer to the literature.[39,40]

Statistical analysis

For analysis at the level of the group, the effects of phase (baseline, treatment phase 1, treatment phase 2) were calculated using ANOVAs for repeated measurements with treatment order as a between subjects factor. ANOVA for repeated measurements requires an equal number of observations per phase. Therefore, multiple scores per phase were averaged: for the Movement ABC and the Praxis Tests the first two measurements (in the baseline condition) were averaged, and for Rhythm Integrated™ the three scores in each phase were averaged. Since the numbers of measurements with the VAS scales were different per phase (due to the randomization of phase lengths and the weekly administration of the VASs) a datareduction was carried out: first, the first measurement of the phase in question was removed, then the remaining number of redundant scores with regular intervals.

Whenever a main effect of phase was found on the ANOVA for repeated measurements, contrasts were used to locate significance. Since an effect of phase may be an effect of time, individual time series were inspected. Per child, the linear trend in the (nonaveraged) scores of the baseline period was compared with the linear trend of the two treatments combined. In this way, the number of children that scored better during treatment than during baseline was established per dependent variable. A sign test was used to determine significance.

The effects of LBD and SI *per se* were analysed separately. One-sample t-tests were used on the gain scores of the relevant phases, against an H_0 of 'no effect'. Differential efficacy was established with a paired t-test on the same gain scores.

The significance of improvements were also analysed per individual child, using the least detectable difference (LDD). The LDD represents the minimum for significant change between two measurements and is calculated by $1.96H\ \sqrt{2}\ H\ \sqrt{\text{SEM}}$.[35] For Rhythm Integrated™, no SEM of a comparable group is available, so individual improvements were not analysed.

Results

Group effects

It has to be noted that, with the exception of the Praxis Tests, lower scores indicate better performance. For the group of children as a whole, repeated measures ANOVAs revealed a significant main effect of phase on all dependent variables (Table 2, cf. Figure 2). There was no significant effect of treatment order (nor a significant interaction with phase), indicating that the subjects starting with LBD fared similarly to those starting with SI (Table 2).

Contrasts revealed a significant advantage of treatments one and two together over baseline for the Movement ABC and the VASs (Table 3) and a significant advantage of treatment two over treatment one for the Praxis Tests and the VASs (Table 3).

On the Movement ABC, analysis of the individual time series revealed that the slope of the line through the scores in the treatment phases (including the last baseline score) was 'better' than that of the line connecting the two baseline scores for all children (Figure 3). This overall pattern was significant on a sign test ($p = 0.02$). Since baseline length was chosen randomly, the improvement can be ascribed to treatment. On the Praxis Tests, Rhythm Integrated™ and the VASs (Figure 4), five out of six children showed improvement during treatment compared to baseline, which is not significant on a sign test ($p = 0.11$).

During LBD, children improved significantly on all dependent variables, while the only significant improvement after SI was found on the VASs (Table 4). When gain scores were compared, improvements on the VASs were equal. On the Movement ABC, the Praxis Tests and Rhythm Integrated™, LBD led to larger improvement than SI. The advantage of LBD on Rhythm Integrated™ was significant ($t = 2.678$; $p < 0.05$).

Individual improvements

On the Movement ABC, five children improved significantly (> one LDD) after both treatment phases. On the Praxis Tests, two children showed significant improvement, and on the VASs, all six of them. There were somewhat more significant improvements after LBD than after SI (Table 5).

Table 2 Repeated measures ANOVAs

	Phase		Treatment order		Interaction	
	$F(2,8)$	p-value	$F(1,4)$	p-value	$F(2,8)$	p-value
Movement ABC	30.052	< 0.001	0.091	0.778	0.998	0.449
Praxis Tests	8.857	0.009	0.260	0.637	1.641	0.253
Rhythm Integrated™	4.588	0.047	1.246	0.327	0.281	0.762
VAS	11.625	0.004	1.337	0.321	0.007	0.994

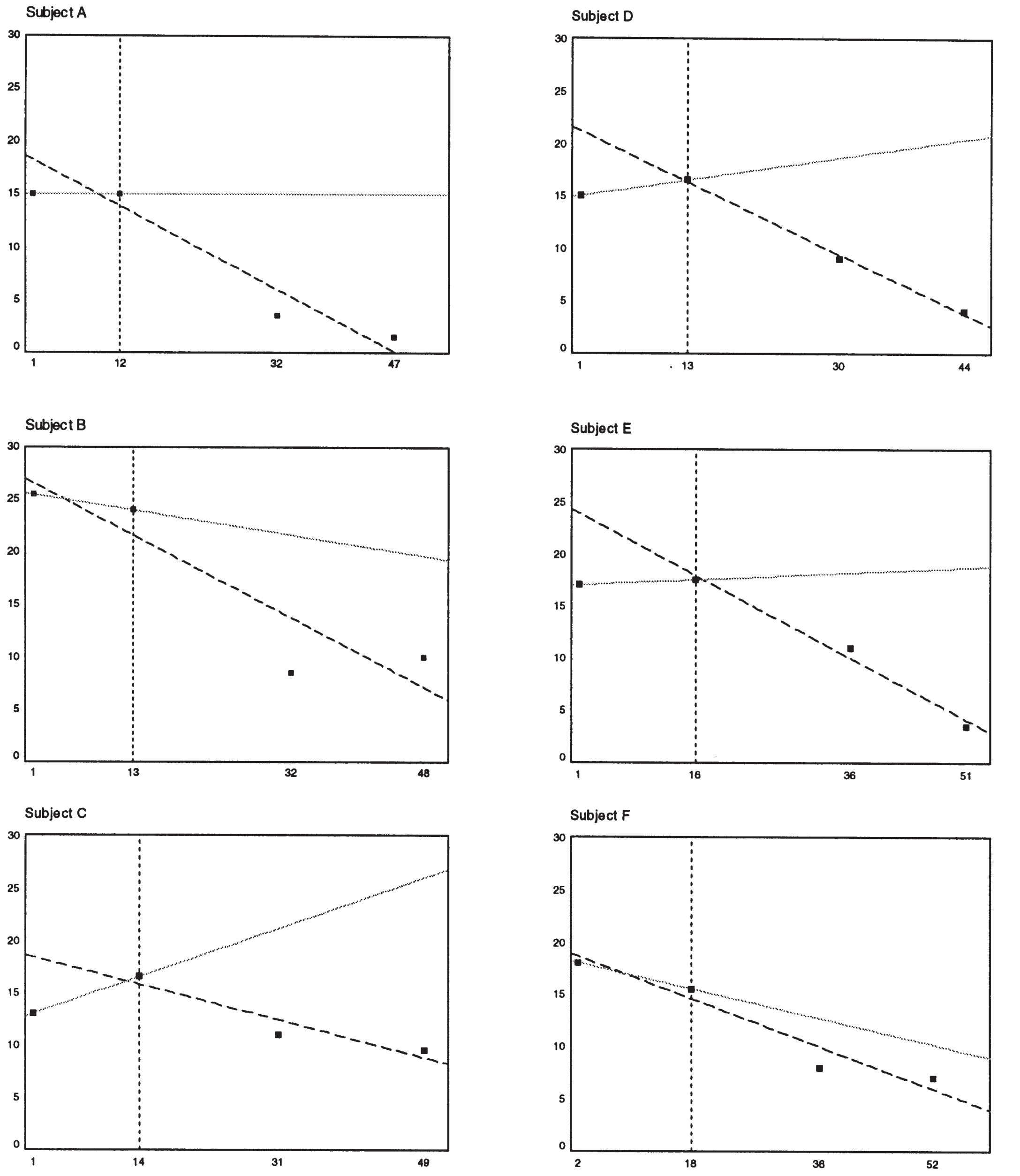

Figure 2 Total scores on the Movement ABC. On the *x*-axis, week numbers are displayed. Note that the length of each phase (baseline, treatment phase 1 and treatment phase 2) is randomized and varies per child between 12 and 18 weeks. On the *y*-axis, scores are displayed, lower scores indicate better performance. Subjects A, B and C (left panels) started with LBD treatment, and subjects D, E and F (right panels) started with SI therapy. Vertical dashed lines indicate the start of treatment. Trend lines were constructed for the baseline condition (solid lines) and for both treatment phases together (dashed lines).

Table 3 Mean scores and contrasts locating significant differences of the repeated measures ANOVAs

	Treatment 1 & 2 vs baseline condition			
	Treatment 1 & 2 Mean score (SD)	Baseline Mean score (SD)	*F*(1,4)	*p*-value
Movement ABC	7.21 (3.27)	17.38 (3.74)	38.140	0.003
Praxis Tests	109.10 (12.17)	101.14 (11.25)	6.888	0.059
Rhythm Integrated™	149.39 (48.02)	197.45 (90.15)	4.441	0.103
VAS	46.64 (19.81)	68.18 (13.87)	11.477	0.028
	Treatment 2 vs treatment 1			
	Treatment 2 Mean score (SD)	Treatment 1 Mean score (SD)	*F*(1,4)	*p*-value
Movement ABC	5.92 (3.46)	8.50 (2.76)	5.587	0.077
Praxis Tests	113.53 (13.09)	104.68 (10.37)	12.818	0.023
Rhythm Integrated™	136.84 (43.52)	161.94 (52.93)	5.472	0.079
VAS	34.74 (17.37)	58.54 (14.90)	11.814	0.026

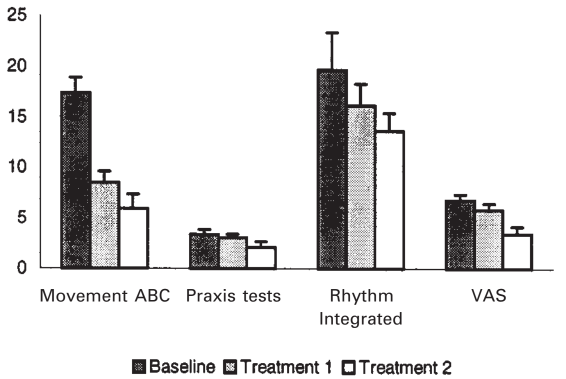

Figure 3 Scores on all dependent variables in the baseline, treatment phase 1 and treatment phase 2. For this graphical representation, scores of the Praxis Tests are transformed into penalty points. Scores of the Praxis Tests, Rhythm Integrated and the VAS are graphically represented in percentages of the true score to avoid visual distortion due to scale differences.

Discussion

It has to be realized that, due to the strict intake procedure applied to keep between-subject variance at a minimum, the study sample was very small. Therefore, results can only be generalized with great caution.

Motor performance of the children with DCD improved significantly after the combination of LBD and SI, and parents were less worried. Methodologically, improvement can result from several forms of bias, such as systematic seasonal effects, nonblind measurement or placebo effects. In the present study, systematic seasonal effects are not likely to have invalidated the results, since phase length was randomized and analysis of the individual trend lines linked improvement to the onset of treatment for at least five out of the six children.

As to nonblind measurement, the Movement ABC and the Praxis Tests were administered by a tester who was blinded to experimental conditions, while Rhythm Integrated™ is a computer registered test, leaving no space for manipulating data. Of course, the VAS scores were not blind, and results can be confounded.

Finally, placebo effects form a threat to internal validity and therefore some placebo components were included in the baseline. On the VAS scores for two children, parental worry diminished during baseline (Figure 4). Maybe these

Clinical messages

- Le Bon Départ could be a valuable 'new' treatment for children with developmental coordination disorder.
- A single subject design with multiple baseline and alternating treatments provides the opportunity to compare different interventions even with a small sample, in situations where clinical symptoms are very difficult to define precisely.

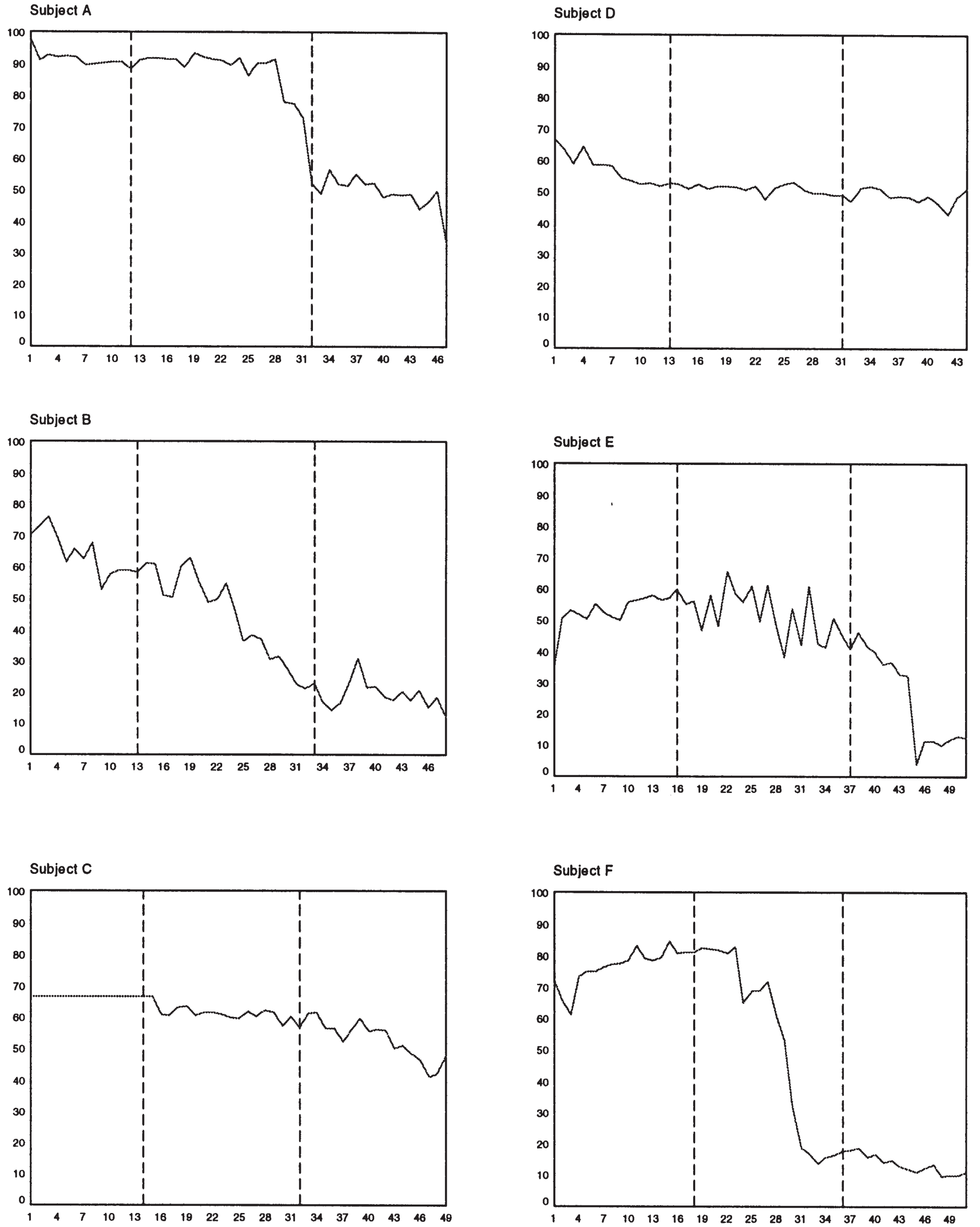

Figure 4 VAS scores. On the *x*-axis, week numbers are displayed. Note that the length of each phase (baseline, treatment phase 1 and treatment phase 2) is randomized and varies per child between 12 and 18 weeks. On the *y*-axis, scores are displayed, lower scores indicate better performance. Subjects A, B and C (left panels) started with LBD treatment, subjects D, E and F (right panels) started with SI therapy. Vertical dashed lines indicate the starts of treatment 1 and treatment 2 respectively.

Table 4 Gainscores after treatment with Le Bon Départ (LBD) and gainscores after treatment with Sensory Integration (SI)

	Gainscores LBD mean (SD)	One-sample *t*-test t_5	p	Gainscores SI mean (SD)	One-sample *t*-test t_5	p
Movement ABC	7.50 (5.57)	–3.298	0.022	3.96 (1.59)	–2.492	0.055
Praxis Tests	7.68 (7.34)	2.565[a]	0.050	4.71 (2.96)	1.589[a]	0.173
Rhythm Integrated	43.01 (15.98)	–2.691	0.043	17.59 (10.14)	–1.735	0.143
VAS	16.62 (6.36)	–2.614	0.047	16.62 (5.60)	–3.002	0.030

[a] Note that on the Praxis Test, higher scores indicate better performance, while on the Movement ABC, Rhythm Integrated™ and the VAS, lower scores indicate better performance.

Table 5 Individual significant improvements

	Movement ABC			Praxis Tests			VAS		
	Tr.1	Tr.2	Total	Tr.1	Tr.2	Total	Tr.1	Tr.2	Total
A	x		x					x	x
B	x		x				x	x	x
C								x	x
D			x		x				x
E			x	x	x	x		x	x
F			x			x	x	x	x

Note that subjects A, B and C started with LBD and received SI as treatment 2, while subjects D, E and F followed this procedure in reversed order.
x = significantly improved.
Tr.1: at the end of treatment 1, compared to the beginning of the study.
Tr.2: at the end of treatment 2, compared to the end of treatment 1.
Total: at the end of treatment 2, compared to the beginning of the study.

parents felt relieved, knowing that something was being done about their child's problems, and the child subsequently improved because his or her parents were more optimistic. Such an effect would have nothing to do with the exact content of the treatment. But then, it would suggest that the baseline did have placebo effects and thus further enhance confidence in the internal validity of the study.

In conclusion, although scores on the VASs must be interpreted with caution, the significant improvement on the Movement ABC, and probably also the improvement on the Praxis Tests and Rhythm Integrated™, can be ascribed to the treatments.

It has been suggested that children with DCD benefit from treatment, whatever the specific components of the treatment.[14] In the present study, however, a significant advantage was found of LBD over SI on Rhythm Integrated™. Given LBD's focus on rhythm, such a specific effect is not surprising.[41] Nevertheless, there were more (nonsignificant) advantages of LBD over SI, while a specific effect of SI on the Praxis Tests was lacking.

The above does not necessarily imply that LBD is 'better' than SI, because our intake procedure focused on children with low scores on the Movement ABC, and the scores on the SIPT were not used as intake criteria. Indeed, initial scores on the Praxis Tests (Table 1) were fairly normal (see ref.[42]), reducing the probability of significant improvement. It can only be concluded that the children with DCD in the present study did better under LBD.

Clinical relevance

Statistical significance is not the same as clinical relevance. On the other hand, since the estimated LDDs were large, significant improvement implies large improvement (Table 5). All subjects showed significant improvement on at least one variable. On the Movement ABC, the mean improvement amounted to 66% of the intake values (Figure 2). On the Praxis Tests the mean advantage was only 12%, but again, initial scores were not very deviant from normal. On Rhythm Integrated™, the children improved by 31%, while the VASs showed a mean improvement of 49%. These numbers appear to be large enough to suggest clinical relevance at the level of the group.

On the Movement ABC, two of the subjects (B, C) still had a 'borderline' motor performance at the end of the study. On Rhythm Integrated™ subjects A, B and C still scored more than two standard deviations below the mean scores of their healthy peers. On the whole, children did improve after treatment, often considerably, but some motor problems remained in some of the children. Improvement was larger after two treatment phases than after just one treatment phase. There is thus the possibility that some of the children need to be treated longer than the approximately 30 hours treatment they had in the present study.

Limitations of the study

By pooling all item scores of each dependent variable into a single average, responsivity increased, but it was impossible to state in any detail which particular aspect of motor performance improved most. For the further development of the rationale underlying treatment, however, this information is essential. Moreover, while the results that were found may be 'a good departure' for LBD, randomized group studies still need to be performed, preferably using the Movement ABC and a test for rhythmic performance. Eventually, it should become possible to differentiate subgroups of children with DCD for whom LBD is particularly suited from other groups more susceptible to other treatment forms. As a final point, no attention was paid to the underlying causes of DCD, or to the components of the treatments that were responsible for the effects. Future studies should address these issues.

Acknowledgements

Our special thanks go to the children and their parents who made this study possible. We thank Karen Dun, Ank Eijkelkamp, Margriet Hagen, Brigitte Lambregts, Claudine Lamoth and Marian Velthuys for their important contributions to the study; Lex Kalverboer, Charles Njiokiktjien, Vladimir Vildavsky and Robert Wagenaar for their help in designing the study; Peter Beek, Bernard Netelenbos, Esther Thelen and Piet van Wieringen for their comments on an earlier version of this paper. Research was made possible by grants from the JANIVO foundation, the Fonds voor Muziektherapie of BUMA/STEMRA, and the Stichting Kinderpostzegels Nederland.

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